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Abstract. Although dysfluent speech is pervasive in spoken conversation, dysfluencies have received little attention within formal theories of dialogue. The majority of work on dysfluent language has come from psycholinguistic models of speech production and comprehension (e.g. [10, 3, 1]) and from structural approaches designed to improve performance in speech applications (e.g. [14, 8]). In this paper, we present a detailed formal account which: (a) unifies dysfluencies (self-repair) with Clarification Requests (CRs), without conflating them, (b) offers a precise explication of the roles of all key components of a dysfluency, including editing phrases and filled pauses, (c) accounts for the possibility of self-addressed questions in a dysfluency.

Keywords: repair, dysfluencies, dialogue semantics

1 Introduction

Although dysfluent speech is pervasive in spoken conversation, dysfluencies have received little attention within formal theories of dialogue. The majority of work on dysfluent language has come from psycholinguistic models of speech production and comprehension (e.g. [10, 3, 1]) and from structural approaches designed to improve performance in speech applications (e.g. [14, 8]).

Recent psycholinguistic studies have shown that both the simple fact that a dysfluency is occuring and its content can have immediate discourse effects—listeners interpret disfluent speech immediately and make use of the information it provides. E.g., [1] found that "filled pauses may inform the resolution of whatever ambiguity is most salient in a given situation", and [2] found that in a situation with two possible referents (yellow v. purple square), the fact that a description was self-corrected (e.g. 'yel- uh purple square') enabled listeners to draw the conclusion that the respective other referent ('purple square') was the correct one, before the correction was fully executed. Moreover, dysfluencies yield information: (1-a) entails (1-b) and defeasibly (1-c), which in certain settings (e.g. legal), given sufficient data, can be useful.

(1) a. Andy: Peter was, well he was fired.
    b. Andy was unsure about what he should say, after uttering 'was'.

until you're	*at the le-*	‖	*I mean*	*at the right-hand*	*edge*
start	reparandum	↑	editing term	alteration	continuation
		moment of interruption			

Fig. 1. General pattern of self-repair

c. Andy was unsure about how to describe what happened to Peter.

In this paper, we present a detailed formal account within the framework KoS [7, 6, for example] which: (a) unifies dysfluencies (*self*-repair) with Clarification Requests (CRs), without conflating them, (b) offers a precise explication of the roles of all key components of a dysfluency, including editing phrases and filled pauses, (c) accounts for the possibility of self-addressed questions in a dysfluency.

We start with background on dysfluencies and on KoS. We then describe in turn our accounts of the two main types of dysfluencies, and end with brief conclusions.

2 Background

2.1 Dysfluencies: structure and taxonomy

As has often been noted (see e.g. [10], and references therein for earlier work), speech dysfluencies follow a fairly regular pattern. The elements of this pattern are shown in Figure 1, annotated with the labels introduced by [14] (who was building on [10]). Of these elements, all but the moment of interruption and the continuation are optional.

We partition the dysfluencies in two: (i) *backward-looking* dysfluencies (BLDs), as in (2-a,b)—the moment of interruption, which need not be followed by an explicit editing phrase, is followed by an alteration that refers back to an already uttered reparandum; (ii) *forward-looking* dysfluencies (FLDs), as in (2-c), where the moment of interruption is followed by a completion of the utterance which is delayed by a filled or unfilled pause (hesitation) or a repetition of a previously uttered part of the utterance (repetition).

(2) a. Flights to Boston I mean to Denver. (Shriberg 1994)
b. Have you seen Mark's erm earphones? Headphones. (British National Corpus, file KP0, l. 369-370)
c. Show flights arriving in uh Boston. (Shriberg 1994)

2.2 Dialogue GameBoards

We start by providing background on the dialogue framework we use here, namely KoS (see e.g. [7, 6]). On the approach developed in KoS, there is actually no single context—instead of a single context, analysis is formulated at a level of information states, one per conversational participant. The dialogue gameboard represents information that arises from publicized interactions. Its structure is given in ((3))—the *spkr,addr* fields allow one to track turn ownership, *Facts* represents conversationally shared assumptions, *Pending* and *Moves* represent respectively moves that are in the process of/have been grounded, *QUD* tracks the questions currently under discussion:[4]

(3) $$\text{DGBType} =_{def} \begin{bmatrix} \text{spkr: Ind} \\ \text{addr: Ind} \\ \text{utt-time : Time} \\ \text{c-utt : addressing(spkr,addr,utt-time)} \\ \text{Facts : Set(Proposition)} \\ \text{Pending : list(locutionary Proposition)} \\ \text{Moves : list(locutionary Proposition)} \\ \text{QUD : poset(Question)} \end{bmatrix}$$

The basic units of change are mappings between dialogue gameboards that specify how one gameboard configuration can be modified into another on the basis of dialogue moves. We call a mapping between DGB types a *conversational rule*. The types specifying its domain and its range we dub, respectively, the *preconditions* and the *effects*, both of which are supertypes of DGBType.

Examples of such rules, needed to analyze querying and assertion interaction are given in (4). Rule (4-a) says that given a question q and ASK(A,B,q) being the LatestMove, one can update QUD with q as QUD–maximal. QSPEC is what characterizes the contextual background of reactive queries and assertions. (4-b) says that if q is QUD–maximal, then subsequent to this either conversational

[4] We also note one fairly minor technical modification to the DGB field QUD, motivated in detail in [4, 6], assuming one wishes to exploit QUD to specify the resolution of non-sentential utterances such as short answers, sluicing, and various other fragments. QUD tracks not simply questions qua semantic objects, but pairs of entities: a question and an antecedent sub-utterance. This latter entity provides a partial specification of the focal (sub)utterance, and hence it is dubbed the *focus establishing constituent* (FEC) (cf. *parallel element* in higher order unification–based approaches to ellipsis resolution e.g. [5].) Thus, the FEC in the QUD associated with a wh-query will be the wh-phrase utterance, the FEC in the QUD emerging from a quantificational utterance will be the QNP utterance, whereas the FEC in a QUD accommodated in a clarification context will be the sub-utterance under clarification. Hence the type of QUD is *InfoStruc*, as defined in (i):

(i) $$\text{Info-struc} = \begin{bmatrix} \text{q : Questn} \\ \text{fec : set(LocProp)} \end{bmatrix}$$

participant may make a move constrained to be q–specific (i.e. either About or Influencing q).[5]

(4) a. Ask QUD–incrementation

$$\begin{bmatrix} \text{pre} & : & \begin{bmatrix} \text{I} & : & \text{InfoStruc} \\ \text{LatestMove} = \text{Ask(spkr,addr,I.q)} & : & \text{IllocProp} \end{bmatrix} \\ \text{effects} & : & \begin{bmatrix} \text{qud} = \left\langle \text{I.q,pre.qud} \right\rangle & : & \text{poset(InfoStruc)} \end{bmatrix} \end{bmatrix}$$

b. QSpec

$$\begin{bmatrix} \text{pre} & : \begin{bmatrix} \text{qud} = \left\langle \text{i, I} \right\rangle : \text{poset(InfoStruc)} \end{bmatrix} \\ \text{effects} & : \text{TurnUnderspec} \wedge_{merge} \begin{bmatrix} \text{r : AbSemObj} \\ \text{R: IllocRel} \\ \text{LatestMove} = \text{R(spkr,addr,r) : IllocProp} \\ \text{c1 : Qspecific(r,i.q)} \end{bmatrix} \end{bmatrix}$$

2.3 Grounding and Clarification

Given a setup with DGBs as just described and associated update rules, distributed among the conversationalists, it is relatively straightforward to provide a unified explication of grounding conditions and the potential for Clarification Requests (or CRification). in the immediate aftermath of a speech event u, **Pending** gets updated with a record of the form of (5) of type *locutionary proposition* (LocProp). Here T_u is a grammatical type for classifying u that emerges during the process of parsing u. The relationship between u and T_u—describable in terms of the proposition p_u given in (5)—can be utilized in providing an analysis of grounding/CRification conditions:

(5) $$p_u = \begin{bmatrix} \text{sit} = \text{u} \\ \text{sit-type} = \text{T}_u \end{bmatrix}$$

(6) a. Grounding: p_u is true: the utterance type fully classifies the utterance token.

b. CRification: p_u is false, either because T_u is weak (e.g. incomplete word recognition) or because u is incompletely specified (e.g. incomplete contextual resolution—problems with reference resolution or sense disambiguation).

[5] We notate the underspecification of the turn holder as‘TurnUnderspec’,, an abbreviation for the following specification which gets unified together with the rest of the rule:

$$\begin{bmatrix} \text{PrevAud} = \{\text{pre.spkr,pre.addr}\} & : & \text{Set(Ind)} \\ \text{spkr} & : & \text{Ind} \\ \text{c1} & : & \text{member(spkr, PrevAud)} \\ \text{addr} & : & \text{Ind} \\ \text{c2} & : & \text{member(addr, PrevAud)} \\ & & \wedge\ \text{addr} \neq \text{spkr} \end{bmatrix}$$

We concentrate here on explicating the coherence of possible CRs. In the aftermath of an utterance u a variety of questions concerning u and definable from u and its grammatical type become available to the addressee of the utterance. These questions regulate the subject matter and ellipsis potential of CRs concerning u and generally have a short lifespan in context. To take one example, the non-sentential CRs in (7-a) and (7-b) are interpretable as in the parenthesized readings. This provides justification for the assumption that the context that emerges in clarification interaction involves the accommodation of an issue—one that for A's utterance in (7), assuming the sub-utterance 'Bo' is at issue, could be paraphrased as (7-c). The accommodation of this issue into QUD could be taken to license any utterances that are co-propositional with this issue, where *CoPropositionality* is the relation between utterances defined in (8).[6] In other words, either a CR which differs from MaxQud at most in terms of its domain, or a correction—a proposition that instantiates MaxQud.

(7) A: Is Bo leaving?
  a. B: Bo? (= Who do you mean 'Bo'?)
  b. B: Who? (= Who do you mean 'Bo'?)
  c. *Who do you mean 'Bo'?*
  d. B: You mean Mo.

(8) *CoPropositionality*
  a. Two utterances u_0 and u_1 are *co-propositional* iff the questions q_0 and q_1 they contribute to QUD are co-propositional.
    (i) qud-contrib(m0.cont) is m0.cont if m0.cont : Question
    (ii) qud-contrib(m0.cont) is ?m0.cont if m0.cont : Prop
    (iii) q_0 and q_1 are co-propositional if there exists a record r such that $q_0(r) = q_1(r)$.

Repetition and meaning–oriented CRs can be specified by means of a uniform class of conversational rules, dubbed *Clarification Context Update Rules (CCURs)* in ([6]). Each CCUR specifies an accommodated MaxQUD built up from a sub-utterance u1 of the target utterance, the maximal element of Pending (*MaxPending*). Common to all CCURs is a license to follow up *MaxPending* with an utterance which is *co-propositional* with MaxQud. (9) is a simplified formulation of one CCUR, Parameter identification, which allows B to raise the issue about A's sub-utterance $u0$: *what did A mean by u0?* (9) underpins CRs such as those in (7).

[6] *CoPropositionality* for two questions means that, modulo their domain, the questions involve similar answers. For instance 'Whether Bo left', 'Who left', and 'Which student left' (assuming Bo is a student) are all co-propositional.

(9) Parameter identification:

$$\begin{bmatrix} \text{pre} & : & \begin{bmatrix} \text{Spkr : Ind} \\ \text{MaxPending : LocProp} \\ \text{u0} \in \text{MaxPending.sit.constits} \end{bmatrix} \\ \text{effects} & : & \begin{bmatrix} \text{MaxQUD} = \begin{bmatrix} \text{q} = \lambda x\text{Mean(A,u0,x)} \\ \text{fec} = \text{u0} \end{bmatrix} : \text{InfoStruc} \\ \text{LatestMove : LocProp} \\ \text{c1: CoProp(LatestMove.cont,MaxQUD.q)} \end{bmatrix} \end{bmatrix}$$

3 From CRs to Dysfluency: Informal Sketch

We argue that dysfluencies can and should be subsumed within a similar account, a point that goes back to [13]: in both cases (i) material is presented publicly, (ii) a problem with some of the material is detected and signalled (= there is a 'moment of interruption'); (iii) the problem is addressed and repaired, leaving (iv) the incriminated material with a special status, but within the discourse context. Concretely for dysfluencies—as the utterance unfolds incrementally questions can be pushed on to QUD about what has happened so far (e.g. *what did the speaker mean with sub-utterance u1*?) or what is still to come (e.g. *what word does the speaker mean to utter after sub-utterance u2*?).

By making this assumption we obtain a number of pleasing consequences. We can:

- **explain similarities to other-corrections**: the same mechanism is at work, differentiated only by the QUDs that get accommodated.
- **explain internal coherence of dysfluencies**: '#I was a little bit + swimming' is an odd dysfluency, it can never mean 'I was swimming' in the way that 'I was a little bit + actually, quite a bit shocked by that' means 'I was quite a bit shocked by that'. Why coherence? Because 'swimming' is not a good answer to 'What did I mean to say when I said 'a little bit'?'.
- **appropriateness changes implicate that original use unreasonable**: examples like (10) involve quantity implicatures. These can be explicated based on reasoning such as the following: *I could have said (reperandum), but on reflection I said (alteration), which differs only in filtering away the requisite entailment.*

  (10) it's basically (the f- + a front) leg [implicature: no unique front leg]

4 Dysfluency Rules

As we have seen, there are various benefits that arrive by integrating CRs and dysfluencies within one explanatory framework. In order to do this we need to extend PENDING to incorporate utterances that are *in progress*, and hence, incompletely specified semantically and phonologically. Conceptually this is a natural step to make. Formally and methodologically this is a rather big step, as it presupposes the use of a grammar which can associate types word by word (or minimally constituent by constituent), as e.g. in Categorial Grammar [15] and Dynamic Syntax [9]. It raises a variety of issues with which we cannot deal in the current paper: monotonicity, nature of incremental denotations, etc.

For our current purposes, the decisions we need to make can be stated independently of the specific grammatical formalism used. The main assumptions we are forced to make concern where PENDING instantiation and contextual instantiation occur, and more generally, the testing of the fit between the speech events and the types assigned to them. We assume that this takes place incrementally. For concreteness we will assume further that this takes place word by word, though examples like (11), which demonstrate the existence of word-internal monitoring, show that this is occasionally an overly strong assumption.

(11) From [11] *We can go straight on to the ye-, to the orange node.*

BLDs are handled by the update rule in ((12)). This indicates that if u0 is a sub-utterance of the maximally–pending utterance, QUD may be updated so that the issue is 'what did A mean by u0', whereas the FEC is $u0$, and the follow up utterance needs to be be co-propositional with MaxQud:

(12) Backwards looking appropriateness repair:

$$\left[\begin{array}{lll} \text{pre} & : & \left[\begin{array}{l} \text{spkr : Ind} \\ \text{addr : Ind} \\ \text{pending} = \left\langle \text{p0,rest} \right\rangle\text{: list(LocProp)} \\ \text{u0 : LocProp} \\ \text{c1: member(u0, p0.sit.constits)} \end{array}\right] \\ \text{effects} & : & \left[\begin{array}{l} \text{MaxQUD} = \\ \left[\begin{array}{l} \text{q} = \lambda x \text{ Mean(pre.spkr,pre.u0,x)} \\ \text{fec = u0} \end{array}\right]\text{:} \\ \text{InfoStruc} \\ \text{LatestMove : LocProp} \\ \text{c2: Copropositional(LatestMove}^{content}\text{,} \\ \text{MaxQUD)} \end{array}\right] \end{array}\right]$$

Given ((12)), (2a,b) can be analyzed as follows: in (2-a) the alteration 'I mean to Denver' provides a direct answer to the issue *what did A mean with the utterance 'to Boston'*; in (2-b) we analyze 'headphones' as a bare fragment ('short answer') which gets the reading 'I mean headphones' given the QUD-maximality of the issue *what did A mean with the utterance 'earphones'*.

Consider now (13). This differs from (2-a) in one significant way–a different editing phrase is used, namely 'no', which has distinct properties from 'I mean'.

(13) From [11]: From yellow down to brown - no - that's red.

Whereas 'I mean' is naturally viewed as a syntactic constituent of the alteration, 'no' cannot be so analyzed. Arguably the most parsimonious analysis[7] involves assimilating this use to uses such as:

(14) a. [A opens freezer to discover smashed beer bottle] A: No! ('I do not want *this* (the beer bottle smashing) to happen')
b. [Little Billie approaches socket holding nail] Parent: No Billie ('I do not want *this* (Billie putting the nail in the socket) to happen')

This use of 'no' involves the expression of a negative attitude towards an event and would, in particular, allow 'no' to be used to express a negative attitude towards an unintended utterance event. We could analyze (13) as involving the utterance 'brown'. Following this, the rule (12) is triggered with the specification QUD.q = what did A mean by FEC? and the FEC = 'brown.' The analysis then proceeds like the earlier cases.

We specify FLDs with the update rule in (15)—given a context where the LatestMove is a forward looking editing phrase by A, the next speaker—underspecified between the current one and the addressee—may address the issue of what A intended to say next by providing a co-propositional utterance:[8]

(15) Forward Looking Utterance rule:

$$\begin{bmatrix} \text{preconds} : \begin{bmatrix} \text{spkr} : \text{Ind} \\ \text{addr} : \text{Ind} \\ \text{pending} = \left\langle \text{p0,rest} \right\rangle : \text{list(LocProp)} \\ \text{u0} : \text{LocProp} \\ \text{c1: member(u0, p0.sit.constits)} \\ \text{LatestMove}^{content} = \text{FLDEdit(spkr,u0)} : \text{IllocProp} \end{bmatrix} \\ \text{effects} : \text{TurnUnderspec} \wedge_{merge} \\ \begin{bmatrix} \text{MaxQUD} = \\ \begin{bmatrix} \text{q} = \lambda x \ \text{MeanNextUtt(pre.spkr,pre.u0,x)} \\ \text{fec} = \text{u0} \end{bmatrix} : \text{InfoStruc} \\ \text{LatestMove} : \text{LocProp} \\ \text{c2: Copropositional(LatestMove}^{content}\text{,MaxQUD)} \end{bmatrix} \end{bmatrix}$$

(15) differs from its BLD analogue, then, in two ways: first, in leaving the turn underspecified and second, by the fact that the preconditions involves the LatestMove having as its content what we describe as an *FLDEdit* move, which we elucidate somewhat shortly. Words like 'uh', 'thee' will be assumed to have

[7] An extended version of this paper considers and rejects resolution based on a contextually available polar question or proposition.
[8] This rule is inspired in part by Purver's rule for *fillers*, (91), p. 92, ([12]).

such a force, hence the utterance of such a word is a prerequisite for an FLD. To make this explicit, we assume that 'uh' could be analyzed by means of the lexical entry in (16):

(16)
$$\left[\begin{array}{l} \text{phon} : \texttt{uh} \\ \text{cat} = \textit{interjection} : \text{syncat} \\ \text{dgb-params} : \left[\begin{array}{l} \text{spkr : IND} \\ \text{addr : IND} \\ \text{MaxPending : LocProp} \\ \text{u0 : LocProp} \\ \text{c1: member(u0, MaxPending.sit.constits)} \\ \text{rest : address(spkr,addr,MaxPending)} \end{array}\right] \\ \text{cont} = \left[\text{c1 : FLDEdit(spkr,addr,MaxPending)}\right] : \text{Prop} \end{array}\right]$$

We demonstrate how to analyze (17):

(17) From [14]: A: Show flights arriving in uh Boston.

After A utters u0= 'in', she interjects 'uh', thereby expressing FLDEdit(A,B,'in'). This triggers the Forward Looking Utterance rule with MaxQUD.q = λx MeanNextUtt(A,'in',x) and FEC = 'in'. 'Boston' can then be interpreted as answering this question, with resolution based on the short answer rule.

Similar analyses can be provided for (18). Here instead of 'uh' we have a lengthened version of 'a', which expresses an FLDEdit moves:

(18) From [11]: A vertical line to a- to a black disk.

Let us return to consider what the predicate 'FLDEdit' amounts to from a semantic point of view. Intuitively, (19) should be understood as 'A wants to say something to B *after* u0, but is having difficulty (so this will take a bit of time)':

(19) FLDEdit(A,B,u0)

This means we could unpack (19) in a number of ways, most obviously by making explicit the utterance-to-be-produced $u1$, representing this roughly as in (20):

(20) $\exists u1$[After(u1,u0) $\wedge$ Want(A,Utter(A,B,u1))]

This opens the way for a more 'pragmatic' account of FLDs, which we will sketch here, one in which (15) could be *derived* rather than stipulated. Once a word is uttered that introduces FLDEdit(A,B,u0) into the context, in other words has an import like (20), this leads to a context akin to ones like (21), that license *inter alia* elliptical constructions like sluicing and anaphora:

(21) a. A: A woman phoned. introduces issue: 'who is the woman that phoned'.

b. A: Max drank some wine. introduces issue: 'what wine did Max drink' .

Indeed a nice consequence of (15), whether we view it as basic or derived, is that it offers the potential to explain cases like (22) where in the aftermath of a filled pause an issue along the lines of the one we have posited as the *effect* of the conversational rule ((15)) actually gets uttered:

(22) a. Carol 133 Well it's (pause) it's (pause) er (pause) what's his name? Bernard Matthews' turkey roast. (BNC, KBJ)
b. Here we are in this place, what's its name? Australia.
c. They're pretty ... um, how can I describe the Finns? They're quite an unusual crowd actually. `http://www.guardian.co.uk/sport/2010/sep/10/small-talk-steve-backley-interview`

On our account such utterances are licensed because these questions are co-propositional with the issue 'what did A mean to say after u0'. Such examples also highlight another feature of KoS's dialogue semantics: the fact that a speaker can straightforwardly answer their own question, indeed in these cases the speaker is the "addressee" of the query. Such cases get handled easily in KoS because turn taking is abstracted away from querying: the conversational rule QSpec, introduced earlier as (4-b), allows either conversationalist to take the turn given the QUD-maximality of q.

Concluding Comment Finally, the account we provide has a strong methodological import: editing phrases like 'no' and 'I mean' select *inter alia* for speech events that include the discompetent products of performance. This means that the latter are also integrated within the realm of semantic competence.

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